Phys 181 2016

Lecture 10

Tues: HW by 5pm

Supp Ex 18, 20

Ch 4 Conc. Q 9, 13

Ch 4 Prob 13, 15, 51, 56

Weds Review Exam I

Fri: Exam I

Projectile motion

In projectile motion:

1) the acceleration is $a_x = 0\,m/s^2$ $a_y = -9.8\,m/s^2$

2) the horizontal and vertical components of the motion are independent and can be analyzed using kinematic equations

$$\left.\begin{aligned} V_{1x} &= V_{0x} + a_x \Delta t \\ x_1 &= x_0 + V_{0x}\Delta t + \tfrac{1}{2} a_x (\Delta t)^2 \\ V_{1x}^2 &= V_{0x}^2 + 2 a_x \Delta x \end{aligned}\right\}$$ similar with $y \leftrightarrow x$

3) the horizontal component of the motion is motion with constant velocity.

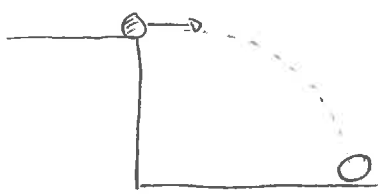
4) the object follows a parabolic trajectory.

(see Fig 4.11 and eq 4.14)

21 Running off a roof

A person runs with speed 8.0 m/s off a flat roof that is 3.0 m above the ground. First suppose that the person travels horizontally at the moment that he leaves the roof. Determine how far horizontally from the edge of the roof the person will land.

a) Sketch the situation with the "earlier" instant being that at which the person leaves the roof and the "later" instant being the moment just before the person hits the ground.

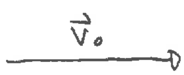


List as many of the variables as possible. Use the format:

$t_0 =$ 0s	$t_1 =$
$x_0 =$ 0m	$x_1 =$
$y_0 =$ 3.0m	$y_1 =$ 0m
$v_{0x} =$ 8.0m/s	$v_{1x} =$
$v_{0y} =$ 0m/s	$v_{1y} =$
$a_x =$ 0m/s^2	$a_y = -9.8$m/s^2

} not zero just before hitting

b) Sketch the velocity vector at the earlier moment and use this to determine the components of $\vec{\mathbf{v}}_0$. Enter these in the list above.



$V_{0x} =$ 8.0m/s

$V_{0y} =$ 0m/s

c) Identify the variable needed to answer the question of the problem. Select and write down a kinematic equation that contains this variable and attempt to solve it.

Need x_1. So $$x_1 = x_0 + v_{0x}\Delta t + \tfrac{1}{2}a_x \Delta t^2$$

$$x_1 = \cancel{0m +} 8.0\text{m/s}\,\Delta t + \cancel{\tfrac{1}{2}\,0\text{m/s}^2\,\Delta t^2}$$

$$x_1 = 8.0\text{m/s}\,\Delta t$$

You should see to solve the variable describing the horizontal position, you first need the value for another, currently unknown variable. Which variable is this?

need t_1 or $\Delta t = t_1 - t_0$

d) Use the vertical aspects of the object's motion to solve for this other unknown variable and use this result to answer the question of this problem.

$$y_1 = y_0 + V_{0y}\,\Delta t + \tfrac{1}{2}a_y(\Delta t)^2$$

$$0m = 3.0m + \cancel{0m/s\,\Delta t} + \tfrac{1}{2}(-9.8\,m/s^2)(\Delta t)^2$$

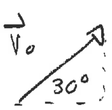
$$-3.0m = -4.9\,m/s^2\,(\Delta t)^2$$

$$(\Delta t)^2 = \frac{-3.0m}{-4.9\,m/s^2} \Rightarrow \Delta t = \sqrt{\frac{3.0}{4.9}\,s^2} \Rightarrow \boxed{\Delta t = 0.78s}$$

So $\quad x_1 = 8.0\,m/s\,\Delta t \Rightarrow x_1 = 8.0\,m/s \times 0.78s \Rightarrow \boxed{x_1 = 6.2m}$

Suppose that the person ran and jumped from the building at an angle of 30° above the horizontal. This will change how far the person travels. Before answering that question, we ask, what is the maximum height above the ground reached by the person for this running jump?

e) Sketch the velocity vector at the earlier moment and use this to determine the components of $\vec{\mathbf{v}}_0$. Reconstruct the list of variables for the problem.



$V_{0y} = V_0 \sin 30^\circ = 8.0\,m/s \sin 30^\circ$
$= 4.0\,m/s$

$V_{0x} = V_0 \cos 30^\circ$
$= 8.0\,m/s \cos 30^\circ = 6.9\,m/s$

$t_0 = 0s$	$t_1 =$
$x_0 = 0m$	$x_1 =$
$y_0 = 3.0m$	$y_1 =$
$V_{0x} = 6.9\,m/s$	$V_{1x} =$
$V_{0y} = 4.0\,m/s$	$V_{1y} = 0\,m/s$

f) Sketch the velocity vector at the instant when the person reaches his highest point. Use this to add additional information to the list of variables for the problem.

$\xrightarrow{\vec{V}_1}$

g) Use the kinematic equations to determine the maximum height that the person reaches.

$$V_{1y}^2 = V_{0y}^2 + 2a_y\,\Delta y$$

$$(0\,m/s)^2 = (4.0\,m/s)^2 + 2(-9.8\,m/s^2)\,\Delta y$$

$$\Rightarrow -16\,m^2/s^2 = -19.6\,m/s^2\,\Delta y \Rightarrow \Delta y = 0.82m$$

So $y_1 = y_0 + \Delta y$
$= 3.0m + 0.82m \Rightarrow \boxed{y_1 = 3.8m}$

Circular motion

There are many objects that move in circular paths. These include:

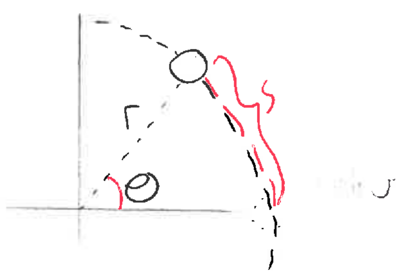
a) ball on a string

b) person on a merry-go-round

c) celestial objects in circular orbits

We briefly develop some of the kinematics that are convenient to describe such motion.

First, position is measured using an angle counterclockwise from the +x axis. This angle is measured in radians. This is an angular unit defined so that



$$\boxed{2\pi \text{ radians} = 360^\circ}$$

With this definition it follows that

> If an object moves in a circle of radius r and sweeps out an angle of θ then the distance (arclength) traveled is
>
> $$s = r\theta$$

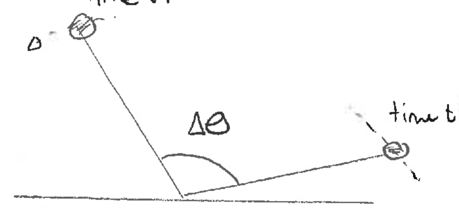
Angular velocity

The rate at which the position of an object in circular motion changes is conveniently described by the rate at which angle changes with time. So

$$\boxed{\text{Angular velocity} = \text{rate at which angle changes}}$$

A definition is:

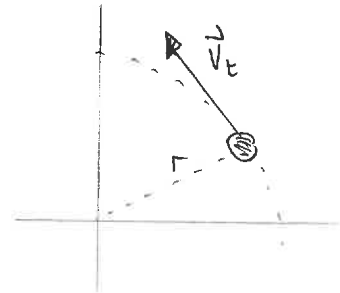
> The angular velocity of an object is
>
> $$\omega = \lim_{\Delta t \to 0} \frac{\Delta\theta}{\Delta t}$$



omega

units: rad/s

Warm Up 1



Demo: PhET Ladybug Revolution

Settings * intro
* no vectors

Observe 20°/s vs 200°/s

The object still has a conventional velocity, now called a tangential velocity, A geometric argument relates the tangential speed to angular velocity via

$$\boxed{v_t = \omega r}$$

Uniform Circular Motion

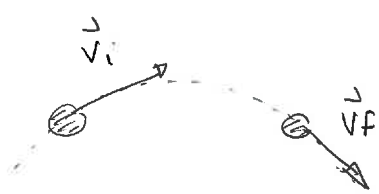
An object which moves:
1) in a circle with constant radius and
2) with constant speed

is said to be in uniform circular motion.

Warm Up 2

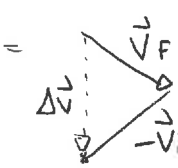
The velocity vector constantly changes direction and thus the acceleration is not zero. We can use

$$\vec{a} = \frac{\Delta \vec{v}}{\Delta t}$$



to determine direction of $\vec{a}$. We find that

$$\Delta \vec{v} = \vec{v}_f - \vec{v}_i =$$



> For uniform motion the acceleration is radially inward with magnitude
>
> $$a = v_t^2/r$$
>
> "centripetal" acceleration